FLORAL DIVERSITY OF GORIGANGA VALLEY IN THE CENTRAL HIMALAYAN HIGHLANDS[1]

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(*With one text-figure*)

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An extensive and intensive survey of the floral diversity of the Goriganga valley in the Central Himalayan ranges was carried out. About 1,081 species of flowering plants belonging to 496 genera and 116 families were recorded. A number of plant taxa were found endemic to the area. The valley was extremely rich in orchid species. Studies showed that a number of plant species, represented by small population sizes recorded earlier, were found no more in the valley. It was concluded that increasing biotic pressures would severely jeopardize the biological wealth of this valley if conservation management plans are not implemented.

Introduction

Himalaya, the youngest mountain system of the world, constitutes an important bridge between floras of northwestern and western Asia, Europe and southern peninsular India on the one hand and the eastern Malesian, northeast Asian, Sino-Japanese and northern Tibetan areas on the other. The Himalayan uplift that took place in a series of orogenies brought about a corresponding change, not only in the climatic profile along the altitudinal gradient, but also in the edaphic factors of these uplands (Kumar and Subramaniam 1985). These changes influenced and paved the way for the immigration of plant species from far off regions, east and west, their establishment in the ecosystems, and speciation and extinction during various geological ages. The trend of colonization and formation of stabilized communities followed by speciation in the Himalaya continued even in the Modern Age (Raina *et al.* 1978, Kumar 1983). Phytogeographically and ecologically, it is, therefore, one of the most complex biomes in the Indian subcontinent with marked east-west and south-north transitions. It serves as a biological platform for overlapping Indo-Chinese and Middle Asiatic amphitheatres (Puri *et al.* 1983).

The geophysical features of the Himalayan region are marked by geological instability, leading to an active process of erosion, massive moraine deposits, precariously perched glacial lakes, avalanches, mudflows, high snowfall and monsoon precipitation. Besides, the biological components, both terrestrial and aquatic, constitute an intricate ecological system of this region. The seral plant communities on the newly stabilized debris fans, in the lower reaches, and moraines in the higher valleys, hold the debris masses, which would otherwise end up in stream and river channels, thereby disrupting the ecological balance of the riverine and riparian ecosystems (Kumar *et al.* 1993). The keystone plant species in various ecosystems in the region are essential for maintenance of their structure and function, including prevention of soil loss and regulation of hydrological cycle (Ehrlich and Mooney 1983). The vegetation cover provides the human population with vital life support and socio-economic security. Timber, fish and medicinal herbs are primary resources for the human population living in these Himalayan highlands on a marginal economy.

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Though studies on the flora of Goriganga valley have been conducted by earlier workers like Sahni and Raizada (1955), Rao (1959), Nair (1966), Arora and Prasad (1980), Pant and Naithani (1981), Rawat (1982), Kalakoti and Pangtey (1982), Kalakoti *et al.* (1983), Malhotra and Balodi (1984 a,b,c,d,e), Malhotra and Balodi (1985), Malhotra *et al.* (1985), Seidenfaden and Arora (1982) and Balodi (1988), they have concentrated only on specific localities or taxa. A comprehensive account of the floristic aspects was not available. This study attempts to present an integrated account of the floristic composition of the valley and changes in recent years.

Study Area

Fig. 1 depicts the study area and location of the Goriganga valley. The valley forms the easternmost part of the Kumaon Himalaya in the vicinity of the Indo-Nepal border. The valley lies between 79° 58' 50" to 80° 29' 36" E long. and 29° 45' 3" to 30° 18' N lat. The Goriganga valley is bounded in the north by the Tibetan plateau and in the east by the Panchachuli ridge, which separates it from the adjoining Dhauliganga valley. The Nanda Devi massif lies northwest, while the Nandakot-Bankatiya ridge marks the western boundary. Kalsin Danda (ridge) marks the southern boundary. The Goriganga river originates from Milam glacier (3,600 m) and traverses a distance of 100 km before merging with River Kali at Jauljibi (600 m). The Goriganga valley, with a catchment area of 2,230 sq. km covers sub-tropical to alpine climatic zones, which coincide with the Lesser, Greater and Tethyan Himalayan geological domains.

The Lesser Himalayan area, south of Munsyari also known as Goriphat, is spread from Jauljibi to Madkot and has the largest human population, with a density of 15 individuals per sq. km. This area is intensively terraced for agriculture and has a rich cultural and ethnic diversity. It enjoys a hospitable climate, numerous freshwater streams, and also harbours a rich and diverse vegetation cover and wildlife.

The Greater Himalayan domain, beginning from Munsyari upstream to Rilkot, is characterised by a harsher climate, narrow valleys, deep gorges and steep slopes prone to massive landslides and avalanches. This area is thickly forested with moru oak (*Quercus floribunda*), kharsu oak (*Q. semecarpifolia*) and mixed broad-leaf coniferous forests. These forest types harbour a rich diversity of economically important species, like timber-yielding trees, medicinal herbs and plants of horticultural value. In the past, this inhospitable terrain had no permanent human settlements, and even today it remains more or less uninhabited.

The region lying beyond the Greater Himalaya, the Tethys, is characterised by gentle relief, wide U-shaped valleys with huge moraine deposits along the river and stream channels having low gradient. The winters are much prolonged with minimum temperature falling to -20 °C, and a high frequency of avalanches. However, the mineral rich moraine deposits, numerous streams and brooks, and gentle gradient of the area offered habitable terrain to earlier human settlers from across the border — the Tibetan highland. They brought with them different social and cultural norms and a different ethnic stock, and occupied the territory extending all along the Tethyan belt in the Himalayan region.

Material and Methods

The plant collections were made during different treks and expeditions to the Milam glacier, Mandakani valley, Sera gad, Rachi gad, Goshi gad, Chhiplakot areas, and the Goriganga valley proper, over a period of two years, in different seasons. The plant specimens were identified with the help of floras and checklists from previous explorations of this area. Some specimens were compared with the type specimen

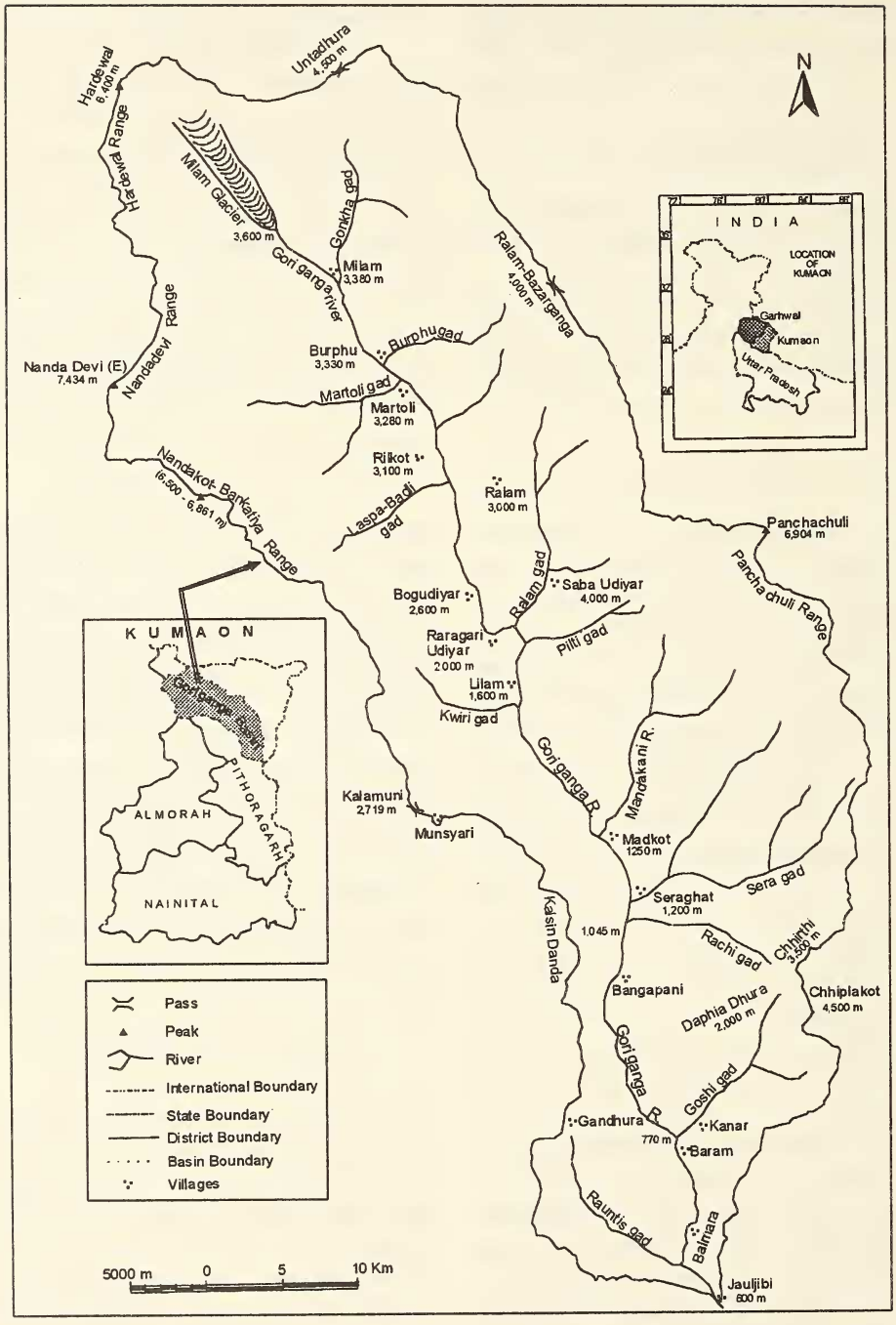

Fig. 1: Location map of Goriganga basin showing major tributaries and places

at the herbarium of the Botanical Survey of India, Dehra Dun. An inventory was prepared after plant collection, recording and authentication of species.

Results and Discussion

Taxonomic Diversity: A total of 1,081 species of flowering plants were recorded (of the more than 3,000 in Himalaya and 20,000 in India). These belong to 496 genera (out of the 2,917 in India) and 116 families (out of the 327 in India). Out of 116 families represented in the valley, 100 are dicots and the rest are monocots, the ratio of monocot to dicot species is 1:4.41 (192 monocots, 850 dicots). The predominant families and the number of genera and species represented by them in the valley are given in Table 1. Among the angiosperm genera, each of the following were represented by 10 or more species: *Potentilla* (19), *Saxifraga* (19), *Astragalus* (13), *Gentiana* (13), *Pedicularis* (13), *Saussurea* (13), *Sedum* (13), *Corydalis* (11), *Stellaria* (11) and *Rubus* (10).

Table 1
PREDOMINANT FAMILIES, THEIR GENERA AND SPECIES IN GORIGANGA VALLEY

Family	Genera	Species
Asteraceae	39	83
Orchidaceae	36	69
Rosaceae	19	69
Poaceae	35	58
Fabaceae	24	55
Ranunculaceae	13	50

New Records of Plant Species: During the past 20 years, many new species have been recorded from the Goriganga valley which are either new records for West Himalaya or Kumaon Himalaya. Malhotra and Balodi (1985) reported *Salix lindleyana* var. *microphylla* and *Epilobium trilectorum*, which are new records for India. Balodi and Malhotra (1984) for the first time recorded *Ribes griffithii* from West Himalaya. *Anemone trullifolia*, *Aconitum atrox*, *Delphinium viscosum* and *Saussurea polystephoides* are the new records for west Himalaya reported by Rawat (1982). Similarly, there have been new records for northwest Himalaya from Goriganga valley: *Crassocephalum crepedioides* by Kalakoti and Pangtey (1982), *Oxalis tetraphylla* by Kalakoti *et al.* (1983), and *Elatostemma sessilis* by Malhotra and Balodi (1985). We also recorded these taxa in Goriganga valley.

The most striking feature of the flora of this area is the number of new records for Kumaon Himalaya. Rawat (1982) reported a number of new species from Goriganga valley which are as follows: *Aconitum atrox*, *Anemone elongata*, *Beibersteinia odora*, *Briza media*, *Chrysoplenium carnuosum*, *Hedinia tibetica*, *Potentilla fruticosa* var. *rigida*, *P. nivea* var. *himalaica*, *Polygonatum graminifolium*, *Sibbaldia cuneata* var. *micrantha* and *Stellaria depauperata*. Arora (1980) reported a number of new species of orchids, namely *Dendrobium porphyrochilum*, *Eria muscicola*, *E. reticosa*, *Gastrochilus acutifolius*, *Kingidium deliciosum*, *Malaxis rheedi*, *Oberonia caulescens*, *O. griffithiana*, *Ponerorchis nana* and *Thelasis longifolium*. Our field studies confirm the presence of all these orchid species in various habitats of the valley. This concentration of orchid species is an unusual feature of western Himalaya, where orchids are not found with such frequency and abundance as in the eastern Himalaya.

Sahni and Raizada (1955), during their expedition to Panchachuli, made new records for the Kumaon Himalaya, namely *Anemone tetrasepala*, *Ranunculus laetus* and *Salix oxycarpa*. Generally, intensive exploration of inhospitable areas leads to the discovery of new plant species. Some of the potential areas in Goriganga valley, which are likely to harbour new plant species are the Ralam valley, Chhiplakot range, Gwars (meadows) in the

Panchachuli and Bankatiya ranges and forests around Bogudiyar.

Endemism: There are nearly 30% dicots endemic to the Himalaya (Puri *et al.* 1983). Some of the endemic Himalayan plant taxa which are also present in the Goriganga valley are *Meconopsis aculeata*, *Ougeinia oojeinensis*, *Cortia lindleii*, *Nardostachys jatamansi*, *Aechmanthera gossypiana*, *Hemiphragma heterophyllum*, *Picrorhiza kurrooa*, *Falconeria himalaica*, *Phlogacanthus thyrsiformis*, *Dodecadenia grandiflora*, *Eria occidentalis* and *Flickingeria hesperis*. The most interesting of these is *Falconeria himalaica*, a rare plant, which was recorded near Munsyari and has a very limited distribution, i.e. only in the Garhwal and Kumaon Himalaya.

Monotypic Genera: Goriganga valley abounds in monotypic genera, which are as follows: *Asperugo procumbens* (Boraginaceae), *Boeninghausinia albiflora* (Rutaceae), *Circaester agrestis* (Circaesteraceae), *Falconeria himalaica* and *Hemiphragma heterophyllum* (Scrophulariaceae), *Cortia lindleii* (Apiaceae), *Parochetus communis*, *Ougeinia oojeinense* (Fagaceae) and *Oxyria digyna* (Chenopodiaceae).

The presence of endemic species and monotypic genera indicates active processes of speciation in this region. Moreover, the majority of these species are polyploids (Kumar and Subramaniam 1985), clearly pointing out their neo-endemic nature (Lewis 1972).

Epiphytic Flora: Angiospermic epiphytes occurring in the valley mostly belong to the families Orchidaceae and Asclepiadaceae. There are 42 epiphytic orchid species, which are described later in this paper. Other epiphytic flora of the valley includes *Hoya lanceolata* and *H. longifolia*. There is an abundance of epiphytic ferns too. *Lycopodium annotinum*, *Polypodium linearis*, *P. flocculosum* are mainly found near Bogudiyar. The richness of the epiphytic flora in the valley seems to be a result of the geophysical environment, marked by the presence of numerous streams, river channels and warm temperate conditions at lower elevations, giving rise to high humidity in which epiphytes thrive.

Parasitic Flora: Parasitic flora in the valley belongs to the families Loranthaceae, Orchidaceae and Orobanchaceae. Partial parasites of family Loranthaceae are *Korthalsella opuntia* on pine (*Pinus roxburghiana)* (at Kanar), *Scurrula elata* on *Rhododendron arboreum* (at Rathi, Bogudiyar and Mandakani valley), *Viscum album* on pine and toon (*Cedrela toona*) (between Madkot and Baram), and *V. articulatum* (around Gandhura and Madkot). The orchids *Corallorhiza trifida* (a root parasite) and *Gastrodia orobanchoides* (a total plant parasite) were recorded from Martoli grasslands and Bhakuna forest in the Mandakani valley, respectively. Obligate parasitic herbs such as *Orobanche cernua*, *O. epithymum* (at Milam) and *O. solmsii* (at Burphu) on the roots of *Thymus serpyllum* were also recorded.

Insectivorous Flora: Rao (1959) recorded a population of the insectivorous *Pinguicula alpina* from Martoli, but only a small patch was observed during the present survey. Similarly, *Utricularia kumaonense* was recorded around Saba Udiyar near Pilti gad bridge by Pant and Naithani (1981). However, this plant could not be found during our surveys in the valley, indicating the possibility of threats to its survival. Such pressures could prove fatal to a species, particularly with small population size, restricted distribution and smaller niche width (Pandit and Babu 1998).

Orchid Flora: The orchids are one of the largest families of flowering plants in the world, but their distribution is restricted. The family is rich in species diversity, but the population sizes are very small. The reasons for their restricted distribution and small populations are the epiphytic habit of the majority of species and their host preference, though not host specificity. These characteristics make them highly

vulnerable to destruction. The felling of even a single tree destroys many well-established orchid individuals, if not species (Kumar *et al.* 1993).

Goriganga valley harbours a rich wealth of orchid flora. There are nearly 69 species, of which 43 (68%) are epiphytic and only a small number are terrestrial, with a few of these being lithophytes (Table 2). About 55-60% of the species are concentrated in the stretch between Balmara, Baram, Goshi gad, Sera gad and Madkot (600-1,200 m). Epiphytic orchids require high relative humidity for growth and survival. Such a high concentration of orchids in this stretch of Goriganga valley is due to its high relative humidity. The various species are usually seen on pine, banj oak (*Quercus leucotrichophora*), toon, mawa (*Engelhardtia spicata*) and rhododendrons. Many of these have preference for a particular tree species.

The orchid laden trees chiefly occur between 800 m and 1,500 m. Most of these trees colonise boulder deposited fans of various channels draining into Goriganga mainly on its left bank. The right bank offers little scope for such trees and orchids to grow, because of steep, exposed slopes where humidity is very low. The one exception to this is Gandhura Reserve Forest block between Balmara and Bangapani, on the right bank of Goriganga, where the trees support many orchid species. The left bank also has highly humid, suitable habitats for orchids to colonise trees. Notable niches of this 'orchid-tree association' are located mainly in the Daphia Dhura reserve forest block and catchments of Goshi gad, Rachi gad and Sera gad. These niches are narrow, with areas varying from 0.5 to 1.0 sq. km. Such microhabitat and niche specificity makes orchid species vulnerable to extinction in the event of small perturbations in their habitat (Reid and Miller 1989).

TABLE 2
EPIPHYTIC ORCHID SPECIES AND THEIR LOCATIONS IN GORIGANGA VALLEY

Plant species	Area
Acampe rigida	Goshi gad
Aerides multiflorum	Kanar
Bulbophyllum affine	Rachi gad fan
B. careyanum	Rachi gad fan
B. cylindraceum	Rachi gad fan
B. polyrhizum	Daphia Dhura
B. reptans var. *acuta*	Gandhura West
B. secundum	Gandhura West
B. cf. *yokunense*	Daphia Dhura
Coelogyne cristata	Daphia Dhura
C. fimbriata	Daphia Dhura
C. ovalis	Goshi gad
C. stricta	Seraghat
Cymbidium hookerianum	Daphia Dhura
Dendrobium amoenum	Goshi gad
D. denudans	Seraghat
D. herbaceum	Goshi gad
D. porphyrochilum	Daphia Dhura
D. primulinum	Daphia Dhura
Eria excavata	Gandhura
E. flava	Madkot
E. muscicola	Kanar
E. occidentalis	Daphia Dhura

Most of the orchid species represented in the valley have phyto-geographical links with those of northeast Himalayan and Sino-Himalayan region. Seidenfaden and Arora (1982) have pointed out that the orchid flora of Goriganga valley is being depleted rapidly by the destruction of the natural habitat on an exponential scale. This means a total extinction of epiphytic orchid species with an irretrievable loss of genetic diversity. Ever-increasing biotic pressure by deforestation has added to this malady. Seidenfaden and Arora (1982) have strongly recommended this area for the establishment of an orchid sanctuary. Considering the fact that such orchid habitats are few and far between in the northwest Himalaya, this recommendation needs to be urgently considered and implemented.

Terrestrial orchids grow in the valley in areas with high relative humidity (70-85%). Moist, thick oak-rhododendron leaf litter, and the alpine meadows of Martoli and Ralam, where there is adequate water supply, are the natural habitats of terrestrial orchid species. These orchids form the ground vegetation in thick

forests of oak (moru, kharsu and banj) and burans (*Rhododendron arboreum*), and on rocks covered with thick layers of moss. Many orchid species were found between Raragari and Bogudiyar, and many more in the Madkani Reserve Forests and meadows of Panchachuli.

During 1980s, ten new orchid species were reported from this area (Arora 1980), which is indicative of its unexplored biological diversity. In some localities, under intense biotic pressure, it is likely that many species have already become extinct which perhaps were never recorded (Kumar *et al.* 1993). There is also every possibility that biological speciation might be arrested in the changed environment due to increasing biotic pressures. Due to all these negative impacts, a number of orchid species have already become rare (17% of the total species) and have been placed in the Red data book (Nayar and Sastry 1987, 1988, 1990). Orchids are important not only from the botanical point of view but also for their high medicinal and ornamental value. Some, like *Dactylorhiza hatagirea,* are of great medicinal value (Kumar 1986, Chopra *et al.* 1992).

Endangered Flora: Topographical variation and diverse microclimatic conditions have led to the formation of many specialised ecological niches and habitats in the Himalayan highlands (Pandit and Babu 1998). Such niches are inhabited by a number of orchid species in the Goriganga valley. Many new species have been recorded in the valley since 1950 by various workers, described earlier, but these species are represented by small populations in a particular habitat. Many of these taxa are endemic to this region, a common feature of the Himalaya (Kumar 1968).

Deforestation at lower limits, over-grazing and indiscriminate collection of medicinal plants in the higher reaches has led to irretrievable loss in the genetic diversity of the Himalaya (Pandit and Babu 1998). Our observations based on field surveys and earlier studies of Arora (1980), Pant and Naithani (1981) and Malhotra and Balodi (1984 a,b,c,d,e), show that several species are rarely seen in the valley, though these were well represented earlier. Table 3 shows some of the species with an endangered status and restricted distribution in the Goriganga valley.

TABLE 3
PLANT SPECIES OF RESTRICTED/RARE OCCURRENCE IN GORIGANGA VALLEY

Botanical Name	Place restricted to
Aconitum deinorrhizum	Saba Udiyar, 4,000 m
Aconitum heterophyllum	Milam, 3,600 m
Arctium lappa	Ralam, 3,000 m
Briza media	Ralam, 3,400 m
Cassia leschenaultiana	Bui-Ralam, 1,500 m
Christolea himalayensis	Ralam glacier, 4,300 m; Untadhura 4,500 m
Codonopsis ovata	Ralam, 3,000 m
Cornus macrophyllus	On way to Bui, 1,500 m
Cymbidium hookerianum	Daphia Dhura, 1,600 m
Cypripedium himalaicum	Bhujani gad, 3,000 m
Elsholtzia ciliata	Ralam, 2,000 m
Eulophia ucbii	Gargia, 900 m
Falconeria himalaica	Panchachuli, 3,800 m; Munsyari, 2,700 m
Gentiana dentosa	Ralam, 4,000 m
Goodyera fusca	Bazarganga-Ralam, 4,000 m
Hypericum monanthemum	Ralam, 4,000 m
Inula grandiflora	Ralam, 4,000 m
Meconopsis aculeata	Ralam, 3,200 m
Nomocharis nana	Ralam, 3,800 m
Oberonia wightiana	Daphia Dhura, 2,000 m
Orchis habenarioides	Ralam, 3,500 m
Podophyllum hexandrum	Ralam, 3,200 m
Rheum moorcroftiana	Chhirthi, 3,000 m
Saussurea bracteosa	Ralam, 3,600 m
Saxifraga flagellaria	On way to Bui, 1,500 m
Sedum heterodontum	Ralam, 2,900 m
S. hookeri	Ralam, 4,000 m
Smithia ciliata	Bui-Ralam, 1,500 m
Utricularia kumaonense	Pilti bridge-Saba Udiyar, 3,000 m
Vigna capensis	Bui-Ralam, 1,800 m

The valley also provides specific habitats to many plant taxa, which are included in the list of 'Threatened Plants of India' by Jain and Sastry (1980). These endangered or threatened species are: *Aconitum deinorrhizum*, *A. heterophyllum*, *Ajuga brachystemma*, *Carex atrata*, *Cerastium thomsonii*, *Corallorhiza*

trifida, *Cypripedium cordigerum*, *C. himalaicum*, *C. insigne*, *Dactylorhiza hatagirea*, *Ephedra gerardiana*, *Eulophia dabia*, *Gastrodia orobanchoides*, *Gentiana kurroo*, *Herminium duthiei*, *Hoya longifolia*, *Kobresia duthiei*, *Lilium polyphyllum*, *Nardostachys grandiflora*, *Orchis habenarioides*, *Podophyllum hexandrum*, *Polygonatum graminifolium*, *P. verticillatum*, *Rheum australe* and *Viola kunawarensis*.

However, some of these plant species are represented by reasonably good population sizes, albeit in areas less frequented by humans and where biotic disturbances are few. The local villagers have been using these species sustainably over centuries. At places some critically endangered species have been brought under cultivation. One important example is that of *Dactylorhiza hatagirea*, now cultivated by the villagers of Milam (3,380 m). Such local efforts need to be made for other species, and may prove to be the best insurance against their extinction.

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